Appendix A-1

Electrically Safe Design of Equipment Checklist

Purpose: This checklist identifies minimum safe design requirements for engineered controls that mitigate exposure of users to electrical hazards which can result in equipment device failure, fire, as well as injury or death by equipment users.

Requirements: Occupational Safety and Health Administration (OSHA) 29CFR 1910.303 through 1910.308, 1910.334 through 1910.335; and 1926.403 through 1926.408 for construction; National Fire Protection Association (NFPA) 70, the National Electric Code (NEC); MIL-HDBK-454 Rev. B or latest version, *Department Of Defense Handbook: General Guidelines For Electronic Equipment*; DA Pam 385-26: The Army Electrical Safety Program.

Applicability: This checklist is a statement of requirements for use by acquisition professionals as part of the request for proposal (RFP) and purchasing activity, by equipment designers and fabricators during development, and by safety professionals/evaluators evaluating equipment for acceptance. It is applicable to equipment that uses or generates electrical current, including batteries.

DOCUMENT CHANGE TABLE			
DATE	AUTHOR	CHANGES MADE	VERSION

Electrically Safe Design of Equipment Checklist

Equipment Make and Model: _____

Date of Design Review: _____

Reviewer Name: _____

Job Title: _____

Email: _____

Phone #: _____

Requirement	Review Criteria	Mil Spec	Legal Requirement
Review all Markings and Documentation look for • Approvals for safety or standards (worldwide)	Has all COTS electrical equipment been listed and certified to a commercial standard by a Nationally Recognized Test Laboratory (NRTL) (e.g., Underwriter's Laboratories (UL), Canadian Standards Association (CSA), or TUV Rheinland (TUV))? Does COTS equipment which has any modifications been recertified by a NRTL?	MIL-HDBK-454B Guideline 1, *Safety Design Criteria*- Personnel Hazards, 4.1 COTS equipment	29 CFR 1910.303(a), Approval and 29 CFR 1926.403(a); NFPA 70/National Electric Code (NEC) Article 100, Definitions, NEC Article 400, Flexible cords and cables
• Review markings for power requirements, operating requirements and/or limitations	Have all guards, barriers, access doors, covers, or plates been marked to indicate the hazard which may be present upon removal of such devices? Is marking located such that it is not removed when the barrier or access door is removed?	MIL-HDBK-454B Guideline 1, Safety Design Criteria- Personnel Hazards, 4.8 Equipment safety markings.	1926.403(i)(2)(iii), Guarding live parts; NEC Article 110, Requirements for electrical installations, working space and guarding; 1910.303(e)(2), Marking durability; 1910.305(j)(3)(iii), Appliances
	Does the design provide positive means to prevent the inadvertent reversing or mis-mating of fittings, couplings, fuel, oil, hydraulic, and pneumatic lines, and mechanical linkage? When prevention of mis-mating by design consideration is not feasible,	MIL-HDBK-454B Guideline 1, 4.7.1 Mechanical interconnection.	NEC Article 314, Outlet, device, pull and junction boxes, conduit bodies, and fittings; NEC Article 604, Manufactured wiring systems;

Requirement	Review Criteria	Mil Spec	Legal Requirement
	is coding or marking employed when approved by the procuring activity? **NOTE**: "Coding and marking will not be approved as a substitute for proper design or items involving explosive, emergency, or safety critical systems."		UL 508A, Industrial control panels; 1926.403(b), Examination, installation and use of equipment
• Review markings for hazards within	Are hazards internal to a unit marked? **NOTE**: Such a case would be a high voltage terminal in a group of low voltage devices. Are Danger, Warning or Caution, signs, labels, tags, and markings used to warn of specific hazards such as voltage, current, thermal, or physical? Are the signs, labels, tags, and markings permanent as the normal life expectancy of the equipment on which they are affixed? Are guards, barriers, access doors, covers or plates marked to indicate the hazard which may be present upon removal of such devices? When possible, is marking located such that it is not removed when the barrier or access door is removed? Have additional, hazards internal to a unit been marked? (Such a case would be a high voltage terminal in a group of low voltage devices.) **NOTE**: MIL-STD-13231, 5.3.2 "High voltage notice, "When AC or DC voltage of 500 volts or more (nominal value) is exposed, including exposure by opening or removal of an access door or cover, is the following notice marked on the article of equipment: DANGER-HIGH VOLTAGE_____VOLTS"	MIL-HDBK-454B Guideline 1, *Safety Design Criteria*-Personnel Hazards, 4.8 Equipment safety markings	NEC Article 110, Requirements for electrical installations; 1910.303(e)(1)(ii), Marking durability; 1926.405(b), Cabinets, boxes and fittings; 1910.305(b)(2), Covers and canopies; 1926.405(j), Equipment for general use; and 29 U.S.C. § 654, 5(a)1, OSH Act General Duty Clause
• Special marks	Are physical hazards marked with color codes in accordance with NEMA Z535.1 where applicable to electronic equipment? **NOTE**: Refer to ANSI/NEMA Z535.1 (R2011) at:	MIL-HDBK-454B Guideline 1, *Safety Design Criteria*-Personnel Hazards, 4.8 Equipment safety markings	1910.335(b), Alerting techniques; 1910.335(b)(1) requires the use of safety signs, safety symbols, or

Requirement	Review Criteria	Mil Spec	Legal Requirement
	http://www.nema.org/Standards/ComplimentaryDocuments/Z535-1-Contents-and-Scope1.pdf For potentials between 70 and 500 volts, are warning signs, labels, or tags in accordance with NEMA Z535.3, NEMA Z535.4, or NEMA Z535.5 and contain the single word "WARNING", and the maximum voltage applicable (e.g., 110 Volts AC power)? For potentials in excess of 500 volts, are warning signs, labels, or tags in accordance with ANSI/NEMA Z535.3, NEMA Z535.4, or NEMA Z535.5 and contain the single word "DANGER", the descriptive words "High Voltage" and the maximum voltage applicable (e.g., High Voltage 550 Volts AC power)? **NOTE**: Web links, NEMA: http://www.nema.org/Pages/default.aspx ANSI/NEMA Z535.4 explanation: http://expediter.com/natm%20pdf%20folder/B%20folder/B9%203%20ANSI%20535-4.pdf ANSI/NEMA Z535.4-2011: http://www.nema.org/Standards/ComplimentaryDocuments/Z535-4-Contents-and-Scope.pdf		accident prevention tags to warn employees about electrical hazards (e.g., electric-arc-flash hazards) which may endanger them as required by §1910.145, Accident prevention signs and tags; NEC Article 110.16, Arc flash hazard warning, Article 110.24, Available fault current field marking; and Article 110.22, Identification of disconnecting means
Review Markings and Documentation • Special marks (continued)	Are physical hazards marked with color codes in accordance with ANSI/NEMA Z535.1, where applicable, to electronic equipment? Is color coding for safety labels on equipment in accordance with ANSI/NEMA Z535.4, "Product Safety Signs and Labels"?	MIL-HDBK-454B Guideline 1, 4.8, Equipment Safety Markings, b., c. & d.	
Review Markings and Documentation • Model numbers and descriptions	Does electric equipment markings placed on the equipment with the manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified; and other markings giving voltage, current, wattage, or other ratings as necessary?	OSHA 1910.303(e)(1)	1910.303(e)(1), Identification and manufacturer ratings; 1926.403(g), Marking; NEC Article 110.21, Markings
Review documentation (manual, etc.) • Look for: hazards in operating; and hazards in opening	Does the design incorporate methods to protect personnel from accidental contact with voltages in excess of 30 volts during normal operation?	MIL-HDBK-454B, Guideline 1 *Safety Design Criteria-Personnel Hazards*, 4.5.3 Accidental contact	1910.303(g)(2), Guarding live parts; 1926.403(i)(2), Working space; 1926.405(b), Examination, installation and use of equipment; NEC

Requirement	Review Criteria	Mil Spec	Legal Requirement
			Article 110.27, Spaces about electric equipment
Review documentation (manual, etc.), look for: • Equip. listings and safety approvals; Quality and ease of use of manual; Equip. sufficient to use safely; Good for repair and maintenance? Are there other hazards besides electrical?			1926.403(b), Electric equipment general requirements, NEC Article 110, Requirements for electrical installations
Review Operational Requirements • Who will use it? • Do they need training to use it? • Are the instructions and markings sufficient? • What hazards does the equipment present to the user?	Are proper instructions given for electrical safety, accident prevention, emergency procedures and first-aid procedures for all persons engaged in electrical work to fully inform them of the hazards?	MIL-HDBK-454B Guideline 1, 5.2 Electrical	1926.408(a)(2)(iii), Equipment isolating means; 1910.332(a-c), Training; 1910.269(a)(2), Training; 1910.269(b)(1), First aid training and CPR
	Are human factors considered when locating and maintaining equipment? **NOTE**: Web link for MIL-STD-1472, DoD Design Criteria Standard, *Human Engineering*: http://www.everyspec.com/MIL-STD/MIL-STD-1400-1499/MIL-STD-1472F_208/	MIL-HDBK-454B Guideline 62, Human Engineering, 5.1 Human engineering	NEC Article 110, Requirements for electrical installations
Where will they use it? • Environmental considerations ○ Outdoors/indoors, temperature, humidity, sand/dirt/moisture, etc. • Duty cycle, how often?	Are un-mated connectors which may contain electrically "hot" circuits while in environmentally hazardous areas covered with moisture proof and vapor proof caps? **NOTE**: Standards: MIL-STD-464, *Electromagnetic Environmental Effects, Requirements for Systems* web link: http://www.everyspec.com/MIL-STD/MIL-STD-0300-0499/MIL-STD-464C_28312/; MIL-DTL-26518, *Connectors, Electrical, Miniature, Rack and Panel, Environment Resistant* web link: http://www.everyspec.com/MIL-SPECS/MIL-SPECS-MIL-DTL/MIL-DTL-26518C_16049/; MIL-HDBK-411, *Power and The Environment for Sensitive DoD Electronic Equipment* web link: http://www.everyspec.com/MIL-HDBK/MIL-HDBK-0300-0499/MIL_HDBK_411B_2135/	MIL-HDBK-454B Guideline 10, Electrical Connectors, 4.12 Protective measures.	1910.305(e), Enclosures for damp or wet locations; NEC Article 504, Safe systems in environmentally hazardous areas; NEC 506.8 (A-J), Acceptable protection techniques for electrical and electronic equipment in hazardous (classified) locations; ANSI/IEC Standard 60529, *Degrees of Protection Provided by Enclosures*
Other Operational Requirements	Are high voltage circuits and capacitors with discharging devices,	MIL-HDBK-454B, Guideline 1,	NEC Article 460, Capacitors;

Requirement	Review Criteria	Mil Spec	Legal Requirement
• Will they need to repair or maintain the device? • What tools and training do they need to maintain it? • Will they need to carry spare parts? • Is reliability an issue? • How is it powered, local facility power, generator, or battery, or both?	unless they discharge to 30 volts or less, within two seconds after power removal?	4.5.5.1 Automatic discharge devices	29 CFR 1910.305(j)(6), Capacitors
	Does the design of all electronic equipment provide fail-safe features for safety of personnel during the installation, operation, maintenance, and repair or interchanging of a complete equipment assembly or component parts thereof?	MIL-HDBK-454B Guideline 1, 4.2 Fail-safe	NEC Article 110, Requirements for Electrical installations; 1926.416(a), Protection of employees
	Are shorting rods provided with all transmitting equipment where voltages exceed of 70 volts rms or DC?	MIL-HDBK-454B, Guideline 1, 4.5.5.2 Shorting rods	1910.269(j), Live line tools
External Visual Inspection – Enclosure • Are the hazards enclosed? • Does the enclosure adequately protect the user from what's inside? • Does the enclosure adequately protect the inside from the environment? • Is the enclosure robust? and • Enough for the application and environment?	Are enclosures designed in accordance with MIL-STD-108, table I for the degree of enclosure best suited to the application? **NOTE**: MIL-STD 108, *Basic Requirements for Enclosures for Electronic Equipment* web link: http://www.everyspec.com/MIL-STD/MIL-STD-0100-0299/MIL_STD_108E_1711/	Reference: MIL-HDBK-454B Guideline 55, "Enclosures" establishes criteria for the design and construction of enclosures. MIL-HDBK-454B Guideline 55, 4.2 Degree of enclosure.	NEC Article 110.73, Equipment working space; 1926.403(i)(2), Guarding live parts; 1910.305(e), Enclosures for wet or damp locations; 1910.305(d), Panel board enclosures; 1910.303(e), Identification of manufacturer and ratings; 1910.335(b), Alerting techniques
	Are internal clearance and equipment mounting holes of racks and panels in accordance with EIA/ECA-310, Electronic Component Association, *Cabinets, Racks, Panels and Associated Equipment*? **NOTE**: Suitable protective measures" are found in MIL-HDBK-454B Guideline 1, Table 1-II for guards and barriers, enclosures, marking, interlocks, and discharge devices.	MIL-HDBK-454B Guideline 55, 4.4 Racks and panels.	NEC Article 110, Requirements for electrical installations; 29 U.S.C. § 654, 5(a)1, OSH Act General Duty Clause
	Are all contacts, terminals and like devices having voltages greater than 30 volts rms or dc with respect to ground guarded from accidental contact by personnel if such points are exposed to contact from operation, inspection or maintenance? Are guards or barriers provided with test probe holes where	MIL-HDBK-454B Guideline 1, 4.5.3.1 Guards and barriers.	29 CFR 1910.303(g)(2) Guarding live parts; NEC Article 110.27, Guarding live parts; 1910.269(u)(4), Guarding of rooms with electrical supply equipment

Requirement	Review Criteria	Mil Spec	Legal Requirement
	maintenance testing is required?		
	Does the design incorporate methods to protect personnel from accidental contact with voltages in excess of 30 volts rms or dc during normal operation?	MIL-HDBK-454B Guideline 1 Safety Design Criteria- Personnel Hazards 4.5.3 Accidental contact.	
External Visual Inspection – Grounding • Is there a hazardous shock voltage inside? • Are there exposed metal parts on the outside? • If yes to both, how is the user protected from shock? ○ Double insulated or grounded • If needed, how is the system grounded?	Does equipment leakage current exceed 3.5 milliamperes dc or rms? When excessive leakage currents are required by design or operational requirements, is redundant grounding or double insulation methods incorporated?	MIL-HDBK-454B Guideline 1, Safety Design Criteria- Personnel Hazards 4.5.2.5 Leakage current.	29 CFR 1926.404(b)(1), Ground fault protection; UL 943, *Ground Fault Circuit Interruptors*; NEC Article 430, Motor branch circuit short circuit and ground fault protection; 1910.304(b)(3), Ground fault protection; NFPA 70B, Chapter 29, Leakage Current Testing; 1910.304(g)(8) and (g)(9), Methods of grounding fixed equipment; NEC Article 250, Bonding and Grounding
	Does the design and construction of equipment, excluding self-powered equipment, ensure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation? Does the design include consideration of ground currents and voltage limits (possible arcing) established on a basis of hazardous location? Are antenna and transmission line terminals at ground potential, except for Radio Frequency (RF) energy on their external surfaces?	MIL-HDBK-454B Guideline 1, Safety Design Criteria- Personnel Hazards 4.5.2 Ground.	
	Do plugs for use with metal cased portable tools and equipment have provisions for automatically grounding the metal frame or case of tools and equipment when the plug is mated with receptacle; and does the grounding pin make first and break last? Are ground connections to shields, hinges and other mechanical parts not used to complete electrical circuits? Does any external or interconnecting cable, where a ground is part of the circuit, carry a ground wire in the cable terminated at both ends in the same manner as the other conductors? **NOTE**: Plugs for use with metal cased portable tools and equipment should have provisions for automatically grounding the metal frame or case of tools and equipment when the plug is mated with receptacle.	MIL-HDBK-454B Guideline 1, *Safety Design Criteria- Personnel Hazards*, 4.5.2.2 Grounding methods.	1926.302(a)(1), Electric power operated tools; 1910.242(a), Powered hand tools - general requirements; NEC Article 110.54, Bonding and equipment grounding conductors; NEC Article 250, Bonding and Grounding; IEEE Standard 142, *Recommended Practice for Grounding of Industrial and Commercial Power Systems*

Requirement	Review Criteria	Mil Spec	Legal Requirement
	Ground connections to shields, hinges, and other mechanical parts should not be used to complete electrical circuits. Any external or interconnecting cable, where a ground is part of the circuit, should carry a ground wire in the cable terminated at both ends in the same manner as the other conductors. In no case, except with coaxial cables, should the shield be depended upon for a current-carrying ground connection. Static and safety grounds should not be used to complete electrical circuits.		
	Are hinges or slides not used for grounding paths? Do panels and doors containing meters, switches, test points, etc., attach or hinged in such a manner as to ensure that they are at the same ground potential as the equipment in which they are mounted, whether in a closed or open position? Does the electrical connection between the door, or panel, and the system tie point exhibit a resistance of 0.1 ohm or less, and have sufficient capacity to ensure the reliable and immediate tripping of equipment overcurrent protection devices? **NOTE**: A ground should be considered satisfactory if the electrical connection between the door, or panel, and the system tie point exhibits a resistance of 0.1 ohm or less, and has sufficient capacity to ensure the reliable and immediate tripping of equipment overcurrent protection devices.	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards, 4.5.2.3 <u>Hinged or slide-mounted panels and doors.</u>	
	Except where a conflict with single-point shield grounding guidelines would be created, is shielding on wire or cable grounded to the chassis or frame? Is the shielding secured to prevent it from contacting exposed current-carrying parts or grounding to the chassis or frame at any point other than the ground termination? Does the shielding end at a sufficient distance from exposed conductors to prevent shorting or arcing between the conductor and the shielding?	MIL-HDBK-454B Guideline 1, 4.5.2.4 <u>Shielding</u> Note: Shielding is a way of isolating current. Shielding involves electrical and magnetic protection and insulation involves physical protection. Shielding has 0 potential because of grounding leaving the primary wire electrically isolated or shielded.	NEC Article 250, Grounding and bonding; ANSI/IEEE C2, *National Electrical Safety Code*

Requirement	Review Criteria	Mil Spec	Legal Requirement
	NOTE: MIL-HDBK-419 *Grounding, Bonding and Shielding for Electronic Equipment and Facilities, Volume 1 and 2* sets grounding, bonding, and shielding applications for electronic equipment and facilities.		
	Is the ground connection to an electrically conductive chassis, or frame mechanically secured by soldering to a spot welded terminal lug or to a portion of the chassis, or frame that has been formed into a soldering lug; or by use of a terminal on the ground wire and then securing the terminal by a screw, nut, and lock-washer? Does the screw fit in a tapped hole in the chassis, or frame; or is it held in a through-hole by a nut? When the chassis, or frame, is made of steel, is the metal around the screw hole plated or tinned to provide a corrosion resistant connection? When aluminum alloys are used, is the metal around the grounding screw, or bolt-hole covered with a corrosion resistant surface film only if the resistance through the film is not more than 0.002 ohm? Is hardware used for mounting of meters, switches, test points, etc. grounded whenever possible?	MIL-HDBK-454B Guideline 1, 5.2.3 Grounding to chassis.	1910.334(g), Grounding; 1910.305(b)(1), Conductors entering boxes, cabinets or fittings; NEC Article 250, Grounding and bonding
	Is electronic equipment to be installed in areas where explosive or fire hazards exist bonded in accordance with MIL-STD-464, *Electromagnetic Environmental Effects* for aerospace systems, MIL-STD-1310, *Bonding, Grounding and Other Techniques for Electromagnetic Compatibility* for shipboard systems, and NFPA 70 (National Electric Code) for facilities, or as otherwise specified in the equipment specification? **NOTE**: MIL-STD 1310 weblink**:** http://www.everyspec.com/MIL-STD/MIL-STD-1300-1399/MIL-STD-1310H_20136/	MIL-HDBK-454B Guideline 1, 4.3 Bonding in hazardous areas.	29 CFR 1910.307, Hazardous (classified) locations; 1926.407, Electrical equipment for hazardous locations
External Visual Inspection – Overcurrent Protection • Is there overcurrent protection?	**NOTE**: MIL-HDBK-454B, Guideline 37, "Circuit Breakers" establishes criteria for the selection and application of circuit breakers; MIL-HDBK-454B, Guideline 39, "Fuses and Fuse Holders" establishes criteria for the selection and application of fuses, fuse-holders, and associated hardware.		NEC Article 240, Overcurrent protection, 1926.404(e) and 1910.304(f), Overcurrent protection; NEC Article 430,
	Is current overload protection provided for primary circuits?	MIL-HDBK-454B, Guideline 8,	

Requirement	Review Criteria	Mil Spec	Legal Requirement
(Fuse or breaker) • If so, is it adequately marked?	Are devices such as fuses, circuit breakers, time delays, cutouts, or solid-state current-interruption devices used to open a circuit whenever an overload condition occurs? Are no overcurrent protective device connected in series with any conductor which is grounded at the power source unless the device simultaneously opens all load conductors in the circuit and no pole operates independently, or as otherwise allowed by the National Electrical Code, NFPA 70? Are protective devices wired-in equipment connected to the load side of the equipment power switch (main circuit power disconnect? For portable equipment, does a separable connector or the attachment plug and receptacle serve as the main circuit power disconnect? (The protective device may be on either the line side or the load side of the equipment on-off switch.)	"Electrical Overload Protection, 4.1.1, Current overload protection.	Motors, motor circuits and controllers
	Is current overload protection for the equipment provided by fuses or circuit breakers? Are circuit breakers not used as switches unless such breakers have been specifically designed and tested for that type service?	MIL-HDBK-454B, Guideline 8, Electrical Overload Protection, 4.2.1 Current overload protection.	
	Are circuit breakers capable of being manually operated to the ON and OFF positions?	MIL-HDBK-454B, Guideline 32, Circuit Breakers 4.2 Manual operation.	
External Visual Inspection – Operation • Are the controls, lights, readouts, etc. well-marked? Markings in a language that the use can read? Controls suitable for the environment and application?			1926.403(g), Marking; NEC Article 430, Marking on motors and controllers
External Visual Inspection – Mounting • Is the equipment stand alone? To be mounted in a vehicle, rack? • If stand alone, is it easy to	Is human engineering applied during development and acquisition of equipment, and facilities which serves to achieve the effective integration of personnel into the design of the system? **NOTE**: The objective of a human engineering effort is to develop or improve the crew/equipment/software interface and to achieve required	MIL-HDBK-454B Guideline 62, Human Engineering, 5.1 Human engineering MIL-STD-1472 provides design criteria which may be selectively applied as guidance for human	NEC Article 110.13, Mounting and cooling of equipment; 29 U.S.C. § 654, 5(a)1, OSH Act General Duty Clause

Requirement	Review Criteria	Mil Spec	Legal Requirement
move? Handles, lifts, etc.? • If mountable, are there adequate mounting points? Do they match the users equipment?	effectiveness of human performance during system operation, maintenance and control, and to make economical demands upon personnel resources, skills, training, and costs.	engineering.	
External Visual Inspection – Environment • From the outside, does the equipment look suitable for the environment? • Moisture, temperature, shock and vibration, etc.	At an ambient temperature of 25°C (77 degrees F), are the operating temperature of control panels and operating controls no greater than 49°C (120 degrees F) and not less than 12°C (54 degrees F) ? Does the temperature of other exposed parts subject to contact by operating personnel not exceed 60°C (140 degrees F)? Is the temperature of all other exposed surfaces not greater than 70°C (158 degrees F)?	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards 4.4 Temperature	1910.303(b)(1), Examination, installation and use of equipment; NEC Article 455.11, Generator marking
Internal Visual Inspection • Can the equipment be opened? • Not sealed, potted, riveted, etc. • Does opening the equipment damage it, negate the warranty, or alter its operational characteristics?	Does the design incorporate methods to protect personnel from accidental contact with voltages in excess of 30 volts rms or dc during normal operation?	MIL-HDBK-454B Guideline 1 Safety Design Criteria-Personnel Hazards, 4.5.3 Accidental contact	1910.303(g)(2), Guarding live parts; 1910.303(h)(5), Working space and guarding; NEC Article 110.26, Clear working space, NEC Articles 490.32-33, Equipment over 1,000 volts, guarding energized parts within a compartment; 490.35, Accessibility of energized parts; 490.40, Visual inspection windows
	Does the design incorporate methods to protect personnel from inadvertent contact with voltages capable of producing shock hazards?	MIL-HDBK-454B Guideline 1, 4.5 Electrical	
	Are all contacts, terminals, and like devices having voltages greater than 30 volts rms or dc with respect to ground guarded from accidental contact by personnel if such points are exposed to contact during direct support or operator maintenance? Are guards or barriers provided with test probe holes where maintenance testing is required?	MIL-HDBK-454B Guideline 1, 4.5.3.1 Guards and barriers	
Inspect the internal grounding • How is the power source ground landed? Adequate? • Are internal metal subsystems adequately bonded together?	Does the design and construction of equipment, excluding self-powered equipment, ensure that all external parts, surfaces, and shields, exclusive of antenna and transmission line terminals, are at ground potential at all times during normal operation? Does the design include consideration of ground currents and voltage limits (possible arcing) established on a basis of hazardous location?	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards 4.5.2 Ground.	1910.304(a)(3), Use of grounding terminals and devices; NEC Articles 490.37, Grounding of devices; and 490.38, Door stops and cover plates

Requirement	Review Criteria	Mil Spec	Legal Requirement
	Are antenna and transmission line terminals at ground potential, except for Radio Frequency (RF) energy on their external surfaces?		
	Except with coaxial cables, is the shield depended upon for a current-carrying ground connection? Are static and safety grounds not used to complete electrical circuits? Does a point on the electrically conductive chassis or equipment frame serve as the common tie point for static and safety grounding? Does a point on the electrically conductive chassis or equipment frame serve as the common tie point for static and safety grounding? Is the path from the tie point to ground a) continuous and permanent? b. Is there ample carrying capacity to conduct safely any fault currents that may be expected by internally generated faults? c. Is impedance sufficiently low to limit the potential above ground and to facilitate the operation of the over-current devices in the circuits? and; d. Does sufficient mechanical strength of the material minimize the possibility of ground disconnection?	MIL-HDBK-454B Guideline 1, Safety Design Criteria 4.5.2.2 Grounding methods.	1926.404(f)(7), Supports, enclosures and equipment to be grounded (non-current carrying metal parts); 1926.404(f)(1), Electrical system grounds; 1910.305(a)(1), Wiring methods, components and equipment for general use
Inspect the internal power management • Is the power source polarized? • If so, is the polarity handled correctly internally? i.e., fuse, switch, etc. • Are the internal wire sizes appropriate for the power cord and overcurrent protection? • Is the power adequate for the device wires, power supply, etc.?	Are means provided so that power may be cut off while installing, replacing, or interchanging a complete equipment, assembly, or part thereof? Is interface with electrical power sources in accordance with the applicable regulations or requirements? If a main power switch is provided, is it clearly labeled as such and cut off all power to the complete equipment? Does equipment that utilizes Uninterruptable Power Supplies (UPS) have provisions to isolate the supply from the equipment?	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards 4.5.1 Power	1926.408(a)(2)(iii), Interrupting and isolating devices; NEC Articles 110.6 Field marking and, 110.8, Working on or near electrical conductors or circuit parts; NEC Article 310, Conductors for general wiring; 1910.333, Selection and use of safe work practices
	Are by-passable interlocks required when voltages exceed of 30 volts or are exposed as the result of an access door, cover, or plate being opened?	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards 4.5.4.1	1910.333(c)(10), Interlocks; NEC Article 490.42, Interlocks

Requirement	Review Criteria	Mil Spec	Legal Requirement
	Does the bypass device design such that closing the associated door, cover or plate will automatically open the bypass device and leave the interlock in position to function normally? Are visual means provided to indicate when the interlock is by-passed? Are non-by-passable interlocks required when any voltage is in excess of 500 volts when exposed as a result of an access door, cover, or plate being opened?	Interlocks.	
Internal Visual Inspection - Thermal management • Are there heat producing components inside, such as large rectifiers? • Is the device adequately cooled? Heat sinks, fans, etc.	Does the design and development electronic equipment provide fail-safe features for safety of personnel during the installation, operation, maintenance, and repair or interchanging of a complete equipment assembly or component parts thereof?	MIL-HDBK-454B Guideline 1, 4.2 Fail-safe.	1910.304(f), Overcurrent protection
Internal Visual Inspection - Voltage separation • Is there any high voltage? Greater than 600 V? • Is the insulation on high voltage adequate? • Is there adequate separation between low voltage and high voltage?	**NOTE**: Power sources capable of supplying high current can be hazardous regardless of the voltage at which they operate because of the arcing and heat generated if an accidental short circuit occurs. Are all power buses supplying 25 amperes or over protected against accidental short-circuiting by tools, jewelry or removable conductive assemblies? Is this accomplished by one or more of the following: a. Use of guards and barriers? b. Sufficient space separation to prevent short circuits? c. Hazard warning - signs and labels?	MIL-HDBK-454B Guideline 1, 5.2.4.1 High current protection.	1910.333(a), Safe work practices; 1910.333(c)(8), Conductive apparel; 1910.303(e), Marking, NEC Article 490, Equipment over 1,000 volts;
	Do materials conform to Guideline 26, Table 26-I, "Arc Resistant Materials"? **NOTE**: The materials listed have passed the minimum guidelines of 115 seconds when subjected to the arc-resistance test of ASTM D 495 and are listed in approximate order of arc resistance.	MIL-HDBK-454B, Guideline 26, Arc Resistant Materials establishes criteria for the selection and application of arc resistant materials used for insulation of electric power circuits, 4.1 Materials	
Internal Visual Inspection - Stored energy • Are there batteries inside?	Capacitors should be selected and applied in accordance with MIL-HDBK-198.	MIL-HDBK-454B Guideline 2, Capacitors 4.1 Selection.	NEC Article 460, Capacitors; NEC Article 480, Storage batteries

Requirement	Review Criteria	Mil Spec	Legal Requirement
• Are there capacitors? If so, determine voltage and energy.	MIL-HDBK-198, *Selection and Use of Capacitors* web link: http://www.everyspec.com/MIL-HDBK/MIL-HDBK-0099-0199/MIL-HDBK-198_21658/		
Environment • Is the equipment inside, suitable for the environment?	At an ambient temperature of 25°C, is the operating temperature of control panels and operating controls not greater than 49°C and not less than 12°C? Does the temperature of other exposed parts subject to contact by operating personnel not exceed 60°C and the temperature of all other exposed surfaces not greater than 70°C?	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards 4.4 Temperature.	NEC Article 110, Requirements for electrical installations
Power Source – Batteries • Determine type of battery, e.g., lead-acid, Lithium-ion, etc. • Are the batteries appropriate for the environment and use? • Are the batteries easily replaceable? • Are they primary (non - rechargeable) or secondary (rechargeable)? • If secondary, is the charger appropriate for the battery technology? • What are the consequences of a battery failure?	Do rechargeable batteries conform to MIL-PRF-8565, DOD-B-24541, MILPRF-49450, DOD-STD-1578, W-B-133, or SAE J537? Do non-rechargeable batteries should conform to MIL-B-29595, MIL-PRF-49471, or ANSI C18.1M?	MIL-HDBK-454B, Guideline 27, Batteries, "establishes the criteria for the selection and application of batteries, including installation and marking criteria." MIL-HDBK-454B, Guideline 27, Batteries , 4.2 Rechargeable batteries MIL-HDBK-454B, Guideline 27, Batteries 4.3 Non-rechargeable batteries	NEC Article 480, Storage batteries
	Are connections, polarity, minimum acceptable voltage for equipment operation, nominal voltage, and type(s) of batteries required marked as applicable in a prominent place on, or adjacent to, the battery compartment?	MIL-HDBK-454B, Guideline 27, Batteries 4.4 Installation marking.	NEC Article 480, Storage batteries
Power Source – External (generator or facility power) • Is the power type appropriate? (voltage, frequency, quality) • Will power quality affect equipment operation (voltage variation, surges, EMI)? • How is a ground established	Does the design incorporate methods to protect personnel from inadvertent contact with voltages capable of producing shock hazards?	MIL-HDBK-454B Guideline 1, 4.5 "Electrical.	1910.303(e), NEC Article 445, Generators
	Does the design of the equipment provide personnel maximum access and safety while installing, operating, and maintaining the equipment? Does equipment design include provisions to prevent accidental pulling out of drawers or rack mounted equipment components?	MIL-HDBK-454B Guideline 1, 4.7 Mechanical.	NEC Article 110, Requirements for electrical installations; 1910.303(g)(2), Guarding live parts; 1910.303(b)(1), Equipment examination; 1910.212,

Requirement	Review Criteria	Mil Spec	Legal Requirement
through the power source? • How do you hook up the equipment to the power source? • Is plug type, replacement, adapters, etc., an issue?	Is suitable protection provided to prevent contact with moving mechanical parts such as gears, fans, and belts when the equipment is complete and operating? Are sharp projections on cabinets, doors, and similar parts avoided? Are doors or hinged covers rounded at the corners and provided with stops to hold them open?		Machine guarding, general requirements; NEC Article 250, Bonding and grounding
	Is a means provided so that power may be cut off while installing, replacing, or interchanging a complete equipment, assembly or part thereof? Is the interface with electrical power sources in accordance with the applicable regulations or requirements? If a main power switch is provided, is it clearly labeled? Does the main power switch cut off all power to the complete equipment? Does equipment that utilizes Uninterruptable Power Supplies (UPS) have provisions to isolate the supply from the equipment?	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards 4.5.1, Power. MIL-HDBK-454B, Guideline 25, Electrical Power, establishes criteria for electrical power.	NEC Article 110, Requirements for electrical installations;1910.303(f)(2), Labeling disconnects; 1910.333(b)(2), Lockout and tagging
	Are electrical power guidelines for airborne and associated equipment in accordance with MIL-HDBK-2084 for maintainability requirements (Failure Mode and Criticality Analysis) for avionic electronics? **NOTE**: MIL-HDBK 2084 establishes maintainability design requirements in military specifications for avionic and electronic systems and equipment: http://www.barringer1.com/mil_files/MIL-HDBK-2084.pdf		
	Are electrical power guidelines for shipboard and associated equipment in accordance with type I or type II of section 300 of MIL-STD-1399, *Military Standard for Shipboard Systems, Electric Power?* MIL-STD-1399: http://www.everyspec.com/MIL-STD/MIL-STD-1300-1399/MIL_STD_1399_300A_647/	MIL-HDBK-454B, Guideline 25, Electrical Power 4.2 Shipboard.	IEEE Standard 45, *Standard for Electrical Installations on Ships*
	Is electrical power guidelines for military ground vehicles in accordance	MIL-HDBK-454B, Guideline 25, Electrical Power.3 Ground	

Requirement	Review Criteria	Mil Spec	Legal Requirement
	with MIL-STD-1275? Web link for MIL-STD-1275, *Characteristics of 28 Volt DC Electrical Systems in Military Vehicles*: http://www.everyspec.com/MIL-STD/MIL-STD-1100-1299/MIL-STD-1275D_5431/ **NOTE:** MIL-HDBK-411, *Power and Environment for Sensitive DoD Electronic Equipment* provides the electrical power guidelines for critical communications and related automatic data processing equipment. Web link for MIL-HDBK-411: http://www.everyspec.com/MIL-HDBK/MIL-HDBK-0300-0499/MIL_HDBK_411B_2135/	vehicles. MIL-HDBK-454B, Guideline 25, Electrical Power 5.1 Critical fixed communications and related automatic data processing facilities.	
Performing Tests • Consider using an ohmmeter to perform ground continuity tests, such as: • Plug ground pin to case; • Between internal metal subassemblies; • Between various discontinuous metal surfaces on the outside. • Do you need more "acceptance" tests for the use? • Shock and vibration • Temperature • Overcurrent tests	Does equipment leakage current exceed 3.5 milliamperes dc or rms? **NOTE**: When excessive leakage currents are required by design or operational requirements, redundant grounding or double insulation methods should be incorporated. Is silver plated copper wire not used in applications involving Army missile systems without certification by the wire manufacturer that it passes the sodium polysulfide test in accordance with ASTM B 298, *Specification for Silver Coated or Soft or Annealed Copper Wire*? (Silver plated copper wire should not be used in conjunction with water-soluble solder fluxes.)	MIL-HDBK-454B Guideline 1, Safety Design Criteria-Personnel Hazards 4.5.2.5 Leakage current.	NEC Article 250, Grounding and bonding
	Is wire stored and handled in such a way to minimize exposure to moisture?	MIL-HDBK-454B, Guideline 20, Electrical Hookup Wire 4.1.4 Silver plated copper wire.	
	Is insulating material evaluated under the actual environmental conditions which apply to the equipment? **NOTE**: The breakdown voltage of a given insulating material is dependent upon electrode size and shape, insulator thickness, temperature, humidity, rate of voltage application, voltage waveform, and voltage frequency.	MIL-HDBK-454B, Guideline 45, Corona and Electrical Breakdown Prevention 5.5, Electrical breakdown testing	NEC Article 240, Overcurrent protection
Tests other than electrical • Pressure, leakage, flow	MIL-STD-1686 provides guidelines for the establishment, implementation, and monitoring of an ESD control program, including identification of Electrostatic Discharge Sensitive (ESDS) items,	MIL-HDBK-454B, Guideline 75, Electrostatic Discharge Control 5.1 ESD control program	

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• Light output • Electric, magnetic, RF fields • X-ray	classification of ESD sensitivity levels, control program elements, extent of program element applicability to each acquisition, protective measures to be employed in equipment design, handling, storage, and packaging of ESDS items, protected work areas, personnel training, ESD audits and program reviews, and tailoring. Appendix A of MIL-STD-1686 provides the criteria and procedure for classifying ESDS parts by test. Appendix B of MIL-STD-1686 identifies and classifies ESDS items. MIL-HDBK-263 provides guidance for the establishment and implementation of an ESD control program in accordance with MIL-STD-1686. Web link for MIL-STD-1686: http://www.everyspec.com/MIL-STD/MIL-STD-1600-1699/MIL-STD-1686C_5522/ Reference: MIL-STD-1310, *Shipboard Bonding, Grounding, and Other Techniques for Electromagnetic Compatibility and Safety* for electromagnetic interference problems to ship operation and performance: http://www.everyspec.com/MIL-STD/MIL-STD-1300-1399/MIL-STD-1310H_20136/	MIL-HDBK-454B, Guideline 29, "Electron Tubes" establishes criteria to support the design and testing of electron tube devices and their application equipment.	
	Are all electronic or electrical devices capable of producing X-radiation designed, fabricated, shielded and operated to keep personnel exposure as low as reasonably achievable?	MIL-HDBK-454B, Guideline 1, 4.6.2 X radiation	1910.1096, Ionizing radiation

Notes:

Legal reference are derived from:

a) 29 CFR 1910 and 1926
b) NFPA 70 (National Electric Code (NEC)) & 70E (Standard for Electrical Safety in the Workplace)